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(54) **Integrated catalytic cracking and olefin producing process**

Integriertes katalytisches Krack- und Olefinen Herstellungsverfahren

Procédé intégré de craquage catalytique et de production d'oléfines

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Description

[0001] This invention relates to a combined catalytic cracking and olefin producing process.

[0002] The emergence of low emissions fuels has created a need to increase the availability of olefins for use in alkylation, oligomerization, MTBE and ETBE synthesis. In addition, a low cost supply of olefins continues to be in demand to serve as feedstock for polyolefin production.

[0003] Fixed bed processes for light paraffin dehydrogenation have recently attracted renewed interest for increasing olefin production. However, these type of processes typically require a high capital investment as well as a high operating cost. It is, therefore, advantageous to increase olefin yield using processes which require only a minimal amount of capital investment. It would be particularly advantageous to increase olefin yield in catalytic cracking processes.

[0004] US-A-4,830,728 discloses a fluid catalytic cracking (FCC) unit which is operated to maximize olefin production. The FCC unit has two separate risers in which different feed streams are introduced. The operation of the risers is designed so that a certain catalyst will act to convert a heavy gas oil in one riser and a different catalyst will act to crack a lighter olefin/naphtha feed in the other riser. Conditions within the heavy gas oil riser are modified to maximize either gasoline or olefin production. The primary means of maximizing production of the desired product is by using a specified catalyst.

[0005] A problem inherent in producing olefin products using FCC units is that the process depends upon a specific catalyst balance to maximize production. In addition, even if a specific catalyst balance can be maintained to maximize overall olefin production, olefin selectivity is generally low due to undesirable side reactions such as extensive cracking, isomerization, aromatization and hydrogen transfer reactions. It is, therefore, desirable that olefin production be maximized in a process which allows a high degree of control over olefin selectivity.

[0006] EP-A-0325437 describes and claims a process for regenerating a coke-contaminated fluid cracking catalyst in a regeneration zone at a pressure in the range from above 240 kPa to 446 kPa and a temperature in the range from 650°C to 815°C while injecting the regeneration zone with enough oxygen-containing regeneration gas to maintain a dense fluid bed of regeneration catalyst, and regenerate the catalyst before returning it to a fluid cracker, comprising,

a) withdrawing a controlled stream of the regenerator catalyst and introducing it into a dehydrogenation zone at a temperature below those prevailing in the regeneration zone, the dehydrogenation zone being located in a catalyst cooler, externally relative to the cracker and regenerator, the amount of the stream being sufficient to supply the endothermic heat of reaction for dehydrogenation of alkanes in the dehydrogenation zone,

b) introducing a feedstream of the alkanes into the dehydrogenation zone in an amount sufficient to maintain hot withdrawn catalyst in a state of fluidization in the catalyst cooler, the state of fluidization existing in a sub-transport regime while maintained at a temperature high enough to convert at least 50% of the alkanes, and concurrently to cool the catalyst,

c) transporting the cooled catalyst from the dehydrogenation zone, the catalyst now at a temperature in the range from 650 to 731°C, to the regeneration zone, and mixing hot catalyst therein with the cooled catalyst; and

d) withdrawing products of dehydrogenation in an effluent stream from the catalyst cooler.

[0007] In one embodiment, the process comprises withdrawing a controlled stream of spent catalyst from the fluid cracker and introducing the spent catalyst directly into the dehydrogenation zone, and transporting the cooled catalyst for flow-controlled introduction into a riser of the fluid cracker, in the lower portion thereof, and in addition, introducing a minor amount relative to the alkanes, of steam into the dehydrogenation zone, the amount being sufficient, in combination with the alkanes to strip hydrocarbons remaining in the spent catalyst.

[0008] In order to overcome problems inherent in the prior art, the present invention provides an integrated catalytic cracking and alkane-dehydrogenation process according to claim 1.

[0009] The catalytic cracking catalyst may comprise a zeolite crystalline framework oxide.

[0010] The feed may comprise at least one component selected from the group consisting of ethane, propane, butane, pentane, hexane, heptane, octane, nonane, decane, isobutane, isopentanes, isohexanes, isoheptanes and iso-octanes.

[0011] The dehydrogenation catalyst may comprise from 0.2-10 wt% carbon.

[0012] The alkane feed may be dehydrogenated to an olefin product stream which comprises at least 1 wt% total olefin.

[0013] The reactivated catalytic cracking catalyst may comprise less than about 0.2 wt% carbon.

[0014] The dehydrogenation of the alkane feed stream with the dehydrogenation catalyst may form a coked dehydrogenation catalyst, and the coked dehydrogenation catalyst may be regenerated under regeneration conditions in the plug flow regeneration system. The plug flow regeneration system may comprise a tubular or empty tower regenerator.

[0015] The process may comprise performing step (a) using fully-regenerated catalyst from step (b). Spent catalyst from step (c) may be passed to the plug-flow regenerator for regeneration.

BRIEF DESCRIPTION OF THE DRAWING

[0016] The present invention is now described with reference to a non-limitative example thereof and with reference to the attached drawing, wherein Fig. 1 is a schematic representation of an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Catalytic cracking is a process which is well known in the art of petroleum refining and generally refers to converting a large hydrocarbon molecule to a smaller hydrocarbon molecule by breaking at least one carbon to carbon bond. For example, large paraffin molecules can be cracked to a paraffin and an olefin, and a large olefin molecule can be cracked to two or more smaller olefin molecules. Long side chain molecules which may be present on aromatic rings or naphthenic rings can also be cracked.

[0018] It has been found that a coked catalytic cracking catalyst can be used to enhance the dehydrogenation of an alkane feed stream to produce an olefin stream. By using a coked catalytic cracking catalyst as the dehydrogenation catalyst, this aspect of the invention can be integrated into the catalytic cracking process to increase olefin yield in the overall reaction scheme. This increased olefin yield is advantageous since the olefin product can be used as a feedstock in other reaction processes to either increase the octane pool in a refinery, or the olefins can be used in the manufacture of gasoline additives which are required to reduce undesirable hydrocarbon emissions. In addition, the process of this invention allows for high olefin selectivity such that a portion of the olefin stream can also be used in other chemicals processes such as polyolefin production.

[0019] In the catalytic cracking step of this invention, the hydrocarbon feed is preferably a petroleum hydrocarbon. The hydrocarbon is preferably a distillate fraction having an initial ASTM boiling range of about 400°F (204.4°C). Such hydrocarbon fractions include gas oils, thermal oils, residual oils, cycle stocks, topped and whole crudes, tar sand oils, shale oils, synthetic fuels, heavy hydrocarbon fractions derived from the destructive hydrogenation of coal, tar, pitches, asphalts, and hydrotreated feed stocks derived from any of the foregoing.

[0020] The hydrocarbon feed is preferably introduced into a riser which feeds a catalytic cracking reactor vessel. Preferably, the feed is mixed in the riser with catalytic cracking catalyst that is continuously recycled.

[0021] The hydrocarbon feed can be mixed with steam or an inert type of gas at such conditions so as to form a highly atomized stream of a vaporous hydrocarbon-catalyst suspension. Preferably, this suspension flows through the riser into the reactor vessel. The reactor vessel is preferably operated at a temperature of about 800-1200°F (426.7 to 648.9°C) and a pressure of about 0-100 psig (1.014 to 7.910 bar).

[0022] The catalytic cracking reaction is essentially quenched by separating the catalyst from the vapor. The separated vapor comprises the cracked hydrocarbon product, and the separated catalyst comprises a carbonaceous material (i.e., coke) as a result of the catalytic cracking reaction.

[0023] The coked catalyst is preferably recycled to contact additional hydrocarbon feed after the coke material has been removed. Preferably, the coke is removed from the catalyst in a regenerator vessel by combusting the coke from the catalyst under standard regeneration conditions. Preferably, the coke is combusted at a temperature of about 900-1400°F (482.2 to 760°C) and a pressure of about 0-100 psig (1.014 to 7.910 bar). After the combustion step, the regenerated catalyst is recycled to the riser for contact with additional hydrocarbon feed.

[0024] The catalyst which is used in this invention can be any catalyst which is typically used to catalytically "crack" hydrocarbon feeds. It is preferred that the catalytic cracking catalyst comprise a crystalline tetrahedral framework oxide component. This component is used to catalyze the breakdown of primary products from the catalytic cracking reaction into clean products such as naphtha for fuels and olefins for chemical feedstocks. Preferably, the crystalline tetrahedral framework oxide component is selected from the group consisting of zeolites, tectosilicates, tetrahedral aluminophophates (ALPOs) and tetrahedral silicoaluminophosphates (SAPOs). More preferably, the crystalline framework oxide component is a zeolite.

[0025] Zeolites which can be employed in accordance with this invention include both natural and synthetic zeolites. These zeolites include gmelinite, chabazite, dachiardite, clinoptilolite, faujasite, heulandite, analcite, levynite, erionite, sodalite, cancrinite, nepheline, lazurite, scolecite, natrolite, offretite, mesolite, mordenite, brewsterite, and ferrierite. Included among the synthetic zeolites are zeolites X, Y, A, L, ZK-4, ZK-5, B, E, F, H, J, M, Q, T, W, Z, alpha and beta, ZSM-types and omega.

[0026] In general, aluminosilicate zeolites are effectively used in this invention. However, the aluminum as well as the silicon component can be substituted for other framework components. For example, the aluminum portion can be replaced by boron, gallium, titanium or trivalent metal compositions which are heavier than aluminum. Germanium can be used to replace the silicon portion.

[0027] The catalytic cracking catalyst used in this invention can further comprise an active porous inorganic oxide catalyst framework component and an inert catalyst framework component. Preferably, each component of the catalyst is held together by attachment with an inorganic oxide matrix component.

[0028] The active porous inorganic oxide catalyst framework component catalyzes the formation of primary products by cracking hydrocarbon molecules that are too large to fit inside the tetrahedral framework oxide component. The active porous inorganic oxide catalyst framework component of this invention is preferably a porous inorganic oxide that cracks a relatively large amount of hydrocarbons into lower molecular weight hydrocarbons as compared to an acceptable thermal blank. A low surface area silica (e.g., quartz) is one type of acceptable thermal blank. The extent of cracking can be measured in any of various ASTM tests such as the MAT (microactivity test, ASTM # D3907-8). Compounds such as those disclosed in Greensfelder. B. S., et al., Industrial and Engineering Chemistry, pp. 2573-83, Nov. 1949, are desirable. Alumina, silica-alumina and silica-alumina-zirconia compounds are preferred.

[0029] The inert catalyst framework component densifies, strengthens and acts as a protective thermal sink. The inert catalyst framework component used in this invention preferably has a cracking activity that is not significantly greater than the acceptable thermal blank. Kaolin and other clays as well as α-alumina, titania, zirconia, quartz and silica are examples of preferred inert components.

[0030] The inorganic oxide matrix component binds the catalyst components together so that the catalyst product is hard enough to survive interparticle and reactor wall collisions. The inorganic oxide matrix can be made from an inorganic oxide sol or gel which is dried to "glue" the catalyst components together. Preferably, the inorganic oxide matrix will be comprised of oxides of silicon and aluminum. It is also preferred that separate alumina phases be incorporated into the inorganic oxide matrix. Species of aluminum oxyhydroxides-γ-alamina, boehmite, diaspore, and transitional aluminas such as α-alumina, β-alumina, γ-alumina, δ-alumina, ε-alumina, κ-alumina, and ρ-alumina can be employed. Preferably, the alumina species is an aluminum trihydroxide such as gibbsite, bayerite, nordstrandite, or doyelite.

[0031] According to this invention, in order to produce an olefin stream, an olefin reaction is commenced by contacting an alkane feed stream with a dehydrogenation catalyst. The alkane feed stream of this invention is preferably a C_2-C_{10} alkane composition. The alkane composition can be either branched or unbranched. Such compositions include ethane. propane, butane, pentane, hexane, heptane, octane, nonane, decane, isobutane, isopentanes, isohexanes, isoheptanes and iso-octanes.

[0032] According to this invention, a coked catalytic cracking catalyst serves as the dehydrogenation catalyst. The coked catalytic cracking catalyst is a catalytic cracking catalyst, as described above, which contains a measurable content of carbonaceous material (i.e., coke) on the catalyst, and which will effectively enhance dehydrogenation of the alkane feed stream to selectively form an olefin product. Preferably, the carbon content of the dehydrogenation catalyst will be in a range of from about 0.2-10 wt %, more preferably from about 0.3-5.0 wt %, most preferably from about 0.4-2.5 wt %.

[0033] The dehydrogenation catalyst can be obtained by any of numerous means. Such means are the subject-matter of further applications EP-A-0 654 519, EP-A-0 564 521, EP-A-0 564 522 and EP-A-0 654 523, all having the same filing date. As one example, the dehydrogenation catalyst can be obtained as a result of a partial or incomplete regeneration of at least a portion of the spent catalyst stream in a FCC unit. One of ordinary skill in the art will be able to attain the desired concentration of coke on the catalytic cracking catalyst using well known means of adjusting temperature, oxygen content or burn time within the regenerator portion of the FCC unit.

[0034] The conversion of alkane to olefin in this invention generally involves a dehydrogenation reaction. In the dehydrogenation reaction, alkanes are converted to olefins and molecular hydrogen. This reaction is highly endothermic. Preferably, the dehydrogenation reaction is carried out at a temperature in a range of from about 800-1600°F (426.7 to 871.1 °C), more preferably about 800-1400°F (426.7 to 760°C).

[0035] The dehydrogenation reaction is somewhat dependent upon pressure. In general, the higher the pressure, the lower the conversion of alkane to olefin. Preferably, the process is carried out at about 0-100 psig (1.014 to 7.910 bar).

[0036] The contact time between the alkane stream and the dehydrogenation catalyst will also affect the yield of olefin product. Typically, optimal contact between the coked catalyst and the alkane stream is attained when the olefin product stream contains a concentration of at least about 1 wt % total iso-olefin. Preferably, alkane vapor residence time will be in a range of from about 0.5-10 seconds, more preferably, about 1.0-5.0 seconds.

[0037] An embodiment of this invention is shown in Fig. 1 in which the dehydrogenation reaction is incorporated into a catalytic cracking process. In the preferred embodiment, a petroleum hydrocarbon is catalytically cracked with an active catalytic cracking catalyst to form a cracked hydrocarbon product. As the catalytic cracking reaction progresses, the active catalytic cracking catalyst becomes coked (i.e., coated with a carbonaceous material). The activity of the catalytic cracking catalyst decreases as the concentration of the coke deposited on the catalyst increases. Eventually, the catalytic cracking catalyst is deactivated to the point where the catalyst is essentially ineffective in enhancing the equilibrium balance of the cracking reaction under the standard cracking conditions. At this point. the catalytic cracking catalyst is considered to be a deactivated cracking catalyst.

[0038] The deactivated cracking catalyst can be reactivated by regenerating the catalyst under standard regeneration conditions. In the present invention it is preferred to regenerate the deactivated cracking catalyst using a plug flow catalyst regeneration system. In this type of system, part of the deactivated catalyst can be regenerated and reused as the dehydrogenation catalyst. and part of the deactivated catalyst can be fully reactivated and reused in a continuous catalytic cracking reaction. Thus, regeneration and recovery of a plurality of catalyst streams need be performed in only one regenerator vessel.

[0039] The plug flow regeneration system of this invention comprises a regenerator in which there is little or no significant back mixing of the reaction mixture, including catalyst components. Preferably, the plug flow regenerator is of a tubular or empty tower design which provides for effectively overall laminar flow of the reaction mixture. These types of regenerators are of the same type of general configuration as typical tubular and tower reactors, such as those described in Perry's Chemical Engineers' Handbook, sixth edition, McGraw-Hill, 1984.

[0040] Preferably, the plug flow regenerator has means for distributing an oxygen containing stream throughout the entire length of the regenerator. This will provide a balanced flow of oxygen within the regenerator to evenly combust carbonaceous material from the deactivated cracking catalyst. Since there is no significant back mixing, the amount of carbon material combusted from the spent catalyst increases as the catalyst progressively flows through the regeneration system. Therefore. the amount of carbonaceous material that is desired to be removed from the deactivated catalyst can be primarily controlled by the residence time within the regenerator as long as the other operating conditions remain relatively constant. Residence times can be selected according to the amount of carbon material that is desired to be removed.

[0041] In this invention at least two regenerated streams are recovered requiring at least two different residence times. One regenerated stream is partially regenerated for use as a dehydrogenation catalyst, and another regeneration stream is a fully regenerated catalyst. Preferably, the partially regenerated catalyst has a carbon content of about 0.2-10 wt %, and the fully reactivated catalyst has a carbon content of less than about 0.2 wt%, based on the total weight of the catalyst.

[0042] A preferred embodiment is shown in Fig. 1 in which the integrated catalytic cracking and alkane dehydrogenation process takes place generally in a FCC unit 10 which includes a tubular or empty tower plug flow regenerator 11, a cracking reactor 12 and a satellite reactor 13. The cracking reactor 12 comprises a main reactor vessel and preferably includes a riser conduit where hydrocarbon feed is injected and initially contacts reactivated catalytic cracking catalyst from the plug flow regenerator 11. The catalytic cracking reaction is initiated as the hydrocarbon feed contacts the catalyst, and continues until the catalyst is separated from the hydrocarbon, typically within the cracking reactor 12. Separation can be accomplished using any of the acceptable FCC separation devices such as cyclone separators.

[0043] After separation, the cracked hydrocarbon product leaves the reactor 12 through a product line 14. The separated catalyst, which has become coked (i.e.. spent) in the cracking reaction, leaves the reactor 12 through a recycle line 15 where the catalyst is sent to the plug flow regenerator 11.

[0044] The plug flow regenerator 11 preferably includes a series of injection means 16a-d for distributing an oxygen containing stream evenly throughout the plug flow regenerator 11 to minimize back mixing. Of course, any of various designs for injecting an oxygen containing stream can be used as long as back mixing is kept to a minimum. After the desired amount of carbonaceous material has been combusted from the spent catalyst, a portion of the catalyst is recovered as dehydrogenation catalyst and sent by line 17 to the satellite reactor 13. The catalyst remaining in the plug flow regenerator 11 continues the regeneration process until the catalyst is fully reactivated for reuse in the cracking reactor 12.

[0045] The satellite reactor 13 can be any type of reactor vessel that is operable under dehydrogenation conditions. For example, the satellite reactor 13 can be a transfer line riser reactor, a slumped bed reactor, a spouting bed reactor or a moving bed reactor. Preferably, the satellite reactor 13 will be capable of supporting a fluid bed catalyst at a density in a range of from about 1-45 lbs of catalyst per cubic foot (16.02 to 720.84 kg catalyst/m^3) of reactor volume.

[0046] As the dehydrogenation catalyst is transported through line 17, alkane feed is injected to initiate the dehydrogenation reaction. The reaction continues until the catalyst is separated from the olefin products within the satellite reactor 13. Separation can be accomplished using any of the acceptable fluidized type of catalyst separation devices such as cyclone separators.

[0047] After separation, the olefin product leaves the satellite reactor 13 through an olefin product line 18. The separated catalyst which is further spent in the dehydrogenation reaction leaves the reactor 13 through a recycle line 19 where it is combined with the spent catalyst in the recycle line 15 and sent back to the plug flow regenerator 11 to repeat the cycle.

[0048] The following Examples (neither of which is in accordance with the invention) illustrate features which are useful in performing the invention.

EXAMPLE 1 illustrates the suitability of partially-coked cracking catalyst for use in dehydrogenating alkanes to yield olefin-containing products.

[0049] An equilibrium zeolite beta FCC catalyst (SiO_2 65.1 wt %; Al_2O_3 wt %; Na_2O 0.28 wt %; REO_2 2.14 wt %) was placed in a fixed bed quartz reactor. The temperature of the reactor was maintained at 1250°F (676.7°C), and the pressure was maintained at 0 psig (0 bar gauge). Six runs were made varying the total carbon content on the catalyst from 0.2 wt % to 2.7 wt %. The catalyst in runs 2-6 was pretreated with a hydrocarbon to increase the base level carbon content, thereby representing a partially regenerated spent catalyst. Iso-butane feed was passed through the reactor at 1 second residence time and GHSV of 1066. The results are shown in Table 1.

Table 1

Run Number	001	002	003	004	005	006
Feed Pre-Treat	none	HCN	HCN	Resid	Resid	Resid
Cat/Oil Pre-Treat	---	5.1	3.0	4.8	3.0	1.8
Carbon Content (wt%)	0.2	0.8	1.1	2.2	2.5	2.7
Feed	i-C_4H_{10}	i-C_4H_{10}	i-C_4H_{10}	i-C_4H_{10}	i-C_4H_{10}	i-C_4H_{10}
Iso-C_4H_{10}						
Conversion (wt%)	45.3	37.8	39.4	33.1	34.3	36.0
Selectivity (%)						
C_1-C_3	55.1	43.8	41.7	35.0	35.6	36.2
n-C_4H_{10}	3.0	0.3	2.2	1.8	1.8	2.0
1-C_4H_8	5.6	7.0	6.3	5.6	5.8	5.8
t-2-C_4H_8	5.9	6.9	6.3	5.6	5.6	5.8
c-2-C_4H_8	5.3	5.6	5.1	4.5	4.6	4.6
Iso-C_4H_8	20.8	31.1	36.4	45.5	45.1	44.0
>C4's	4.4	5.5	2.1	1.4	1.5	1.6
Iso-C_4H_8 Yield (wt%)	9.4	11.7	14.3	15.0	15.5	15.8

EXAMPLE 2 illustrates partial regeneration of spent (coked) catalyst in a plug flow regenerator.

[0050] Spent zeolite catalytic cracking catalyst is passed through a tubular plug flow regenerator, which is operated at 1 atm (1.014 bar gauge) and 1280°F (693.3°C). At various residence times within the regenerator, cracking catalyst is recovered and the amount of carbon material removed during the regeneration process is calculated. The results are shown in Table 1.

Table 1

Time. min.	wt % coke removed
0	0
1.25	43.8
2.5	74.0
3.75	86.3
5.0	92.3

[0051] Having now fully described this invention, it will be appreciated by those skilled in the art that the invention can be performed within a wide range of parameters within what is claimed in the claims which follow.

Claims

1. An integrated catalytic cracking and alkane-dehydrogenation process comprising the following steps:

(a) catalytically cracking a petroleum hydrocarbon with active catalytic cracking catalyst to form a cracked hydrocarbon product and deactivated cracking catalyst;

(b) passing deactivated catalyst into a plug-flow regeneration system and separately recovering therefrom a partially-regenerated catalyst useful as an alkane-dehydrogenation catalyst and fully-regenerated catalyst useful as a petroleum hydrocarbon cracking catalyst;

(c) dehydrogenating a feed comprising one or more C_2-C_{10} alkanes employing partially-regenerated catalyst recovered in step (b).

2. The process of claim 1, wherein the catalytic cracking catalyst comprises a zeolite crystalline framework oxide.

3. The process of claim 1 or claim 2, wherein the feed comprises at least one component selected from the group consisting of ethane, propane, butane, pentane, hexane, heptane, octane, nonane, decane, isobutane, isopentanes, isohexanes, isoheptanes and iso-octanes.

4. The process of any preceding claim, wherein the dehydrogenation catalyst comprises from 0.2-10 wt % carbon.

5. The process of any preceding claim, wherein the alkane feed is dehydrogenated to an olefin product stream which comprises at least 1 wt % total olefin.

6. The process of any preceding claim, wherein the reactivated catalytic cracking catalyst comprises less than about 0.2 wt % carbon.

7. The process of any preceding claim, wherein the dehydrogenation of the alkane feed stream with the dehydrogenation catalyst forms a coked dehydrogenation catalyst and the coked dehydrogenation catalyst is regenerated under regeneration conditions in the plug flow regeneration system.

8. The process of any preceding claim, wherein the plug flow regeneration system comprises a tubular or empty tower regenerator.

9. The process of any preceding claim comprising performing step (a) using fully-regenerated catalyst from step (b).

10. The process of any one of claims 1 to 9 comprising passing spent catalyst from step (c) to the plug-flow regenerator for regeneration.

Patentansprüche

1. Integriertes katalytisches Crack- und Alkan-Dehydrierungsverfahren, das die folgenden Schritte umfaßt:

(a) katalytisches Cracken eines Erdölkohlenwasserstoffs mit einem aktiven katalytischen Crackkatalysator, um ein gecracktes Kohlenwasserstoffprodukt und deaktivierten Crackkatalysator zu bilden,

(b) Führen des deaktivierten Katalysators in ein Pfropfenströmungsregenerationssystem und separate Gewinnen daraus eines partiell regenerierten Katalysators, der als Alkan-Dehydrierungskatalysator brauchbar ist, und eines vollständig regenerierten Katalysators, der als Erdölkohlenwasserstoffcrackkatalysator brauchbar ist,

(c) Dehydrieren eines Einsatzmaterials, das ein oder mehrere C_2- bis C_{10}-Alkane umfaßt, wobei in Schritt (b) gewonnener partiell regenerierter Katalysator verwendet wird.

2. Verfahren nach Anspruch 1, bei dem der katalytische Crackkatalysator ein kristallines Zeolithgerüstoxid umfaßt.

3. Verfahren nach Anspruch 1 oder Anspruch 2, bei dem das Einsatzmaterial mindestens eine Komponente ausgewählt aus der Gruppe bestehend aus Ethan, Propan, Butan, Pentan, Hexan, Heptan, Octan, Nonan, Decan, Isobutan, Isopentanen, Isohexanen, Isoheptanen und Isooctanen umfaßt.

4. Verfahren nach einem der vorhergehenden Ansprüche, bei dem der Dehydrierungskatalysator 0,2 bis 10 Gew.-% Kohlenstoff umfaßt.

5. Verfahren nach einem der vorhergehenden Ansprüche, bei dem das Alkaneinsatzmaterial zu einem Olefinproduktstrom dehydriert wird, der insgesamt mindestens 1 Gew.-% an Olefin umfaßt.

6. Verfahren nach einem der vorhergehenden Ansprüche, bei dem der reaktivierte katalytische Crackkatalysator weniger als etwa 0,2 Gew.-% Kohlenstoff umfaßt.

7. Verfahren nach einem der vorhergehenden Ansprüche, bei dem die Dehydrierung des Alkaneinsatzmaterialstroms mit dem Dehydrierungskatalysator einen verkokten Dehydrierungskatalysator bildet und der verkokte Dehydrierungskatalysator unter Regenerationsbedingungen in dem Pfropfenstömungsregenerationssystem regeneriert wird.

8. Verfahren nach einem der vorhergehenden Ansprüche, bei dem das Pfropfenströmungsregenerationssystem einen Rohr- oder leeren Turm-Regenerator umfaßt.

9. Verfahren nach einem der vorhergehenden Ansprüche, bei dem Schritt (a) unter Verwendung von vollständig regeneriertem Katalysator aus Schritt (b) durchgeführt wird.

10. Verfahren nach einem der Ansprüche 1 bis 9, bei dem verbrauchter Katalysator aus Schritt (c) zu dem Pfropfenströmungsregenerator für die Regeneration geführt wird.

Revendications

1. Procédé intégré de craquage catalytique et de déshydrogénation d'alcanes comprenant les étapes consistant :

   (a) à craquer catalyliquement un hydrocarbure de pétrole par un catalyseur de craquage catalytique actif pour former un produit hydrocarboné craqué et un catalyseur de craquage désactivé,
   (b) à faire passer le catalyseur désactivé dans un système de régénération à écoulement par bouchons et à en récupérer séparément un catalyseur partiellement régénéré utilisable comme catalyseur de déshydrogénation d'alcanes et un catalyseur complètement régénéré utilisable comme catalyseur de craquage d'hydrocarbures de pétrole, et
   (c) à déshydrogéner une charge d'alimentation comprenant un ou plusieurs alcanes en C_2-C_{10} en employant le catalyseur partiellement régénéré récupéré à l'étape (b).

2. Procédé selon la revendication 1, dans lequel le catalyseur de craquage catalytique comprend un oxyde à ossature cristalline de zéolite.

3. Procédé selon la revendication 1 ou 2, dans lequel la charge d'alimentation comprend au moins un composant choisi dans le groupe constitué par l'éthane, le propane, le butane, le pentane, l'hexane, l'heptane, l'octane, le nonane, le décane, l'isobutane, les isopentanes, les isohexanes, les isoheptanes et les isooctanes.

4. Procédé selon l'une quelconque des revendications précédentes, dans lequel le catalyseur de déshydrogénation comprend 0,2% à 10% en poids de carbone.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel la charge d'alimentation d'alcanes est déshydrogénée en un courant de produit oléfinique qui comprend au moins 1% en poids d'oléfine au total.

6. Procédé selon l'une quelconque des revendications précédentes, dans lequel le catalyseur de craquage catalytique réactivé comprend moins d'environ 0,2% en poids de carbone.

7. Procédé selon l'une quelconque des revendications précédentes, dans lequel la déshydrogénation du courant d'alimentation d'alcanes par le catalyseur de déshydrogénation forme un catalyseur de déshydrogénation cokéfié et le catalyseur de déshydrogénation cokéfié est régénéré dans des conditions de régénération dans le système de régénération à écoulement par bouchons.

8. Procédé selon l'une quelconque des revendications précédentes, dans lequel le système de régénération à écoulement par bouchons comprend un régénérateur tubulaire à tour ou vide.

9. Procédé selon l'une quelconque des revendications précédentes, comprenant la réalisation de l'étape (a) en utilisant le catalyseur complètement régénéré de l'étape (b).

10. Procédé selon l'une quelconque des revendications 1 à 9, comprenant l'étape consistant à faire passer le catalyseur épuisé de l'étape (c) dans le régénérateur à écoulement par bouchons pour effectuer sa régénération.

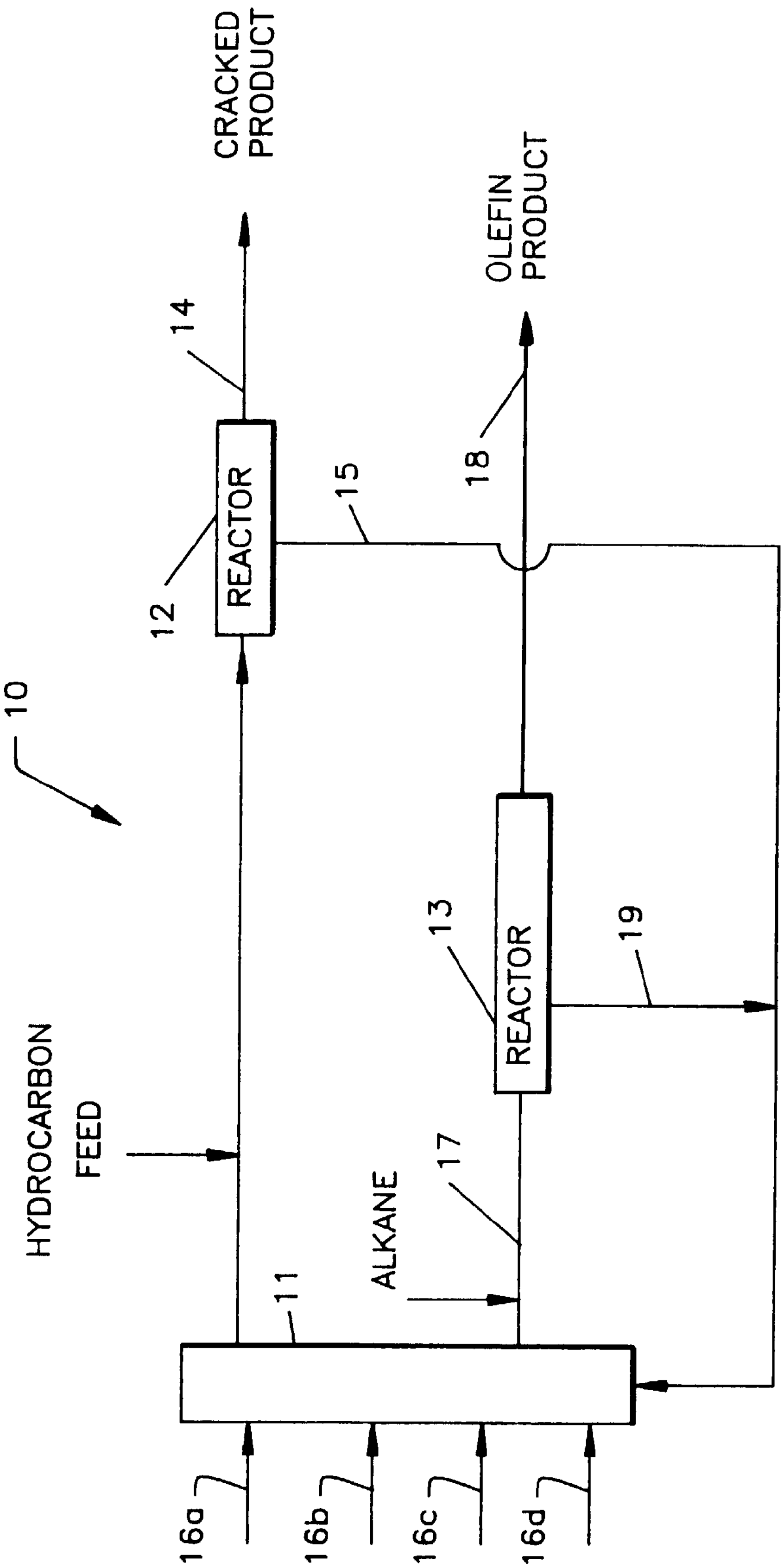
CRACKED PRODUCT
OLEFIN PRODUCT
14
REACTOR
12
15
18
10
REACTOR
13
19
HYDROCARBON FEED
ALKANE
17
11
16a
16b
16c
16d

FIG. 1